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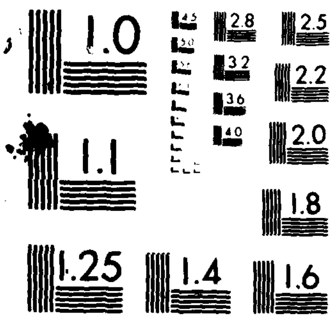

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EXAMINING THE FEASIBILITY OF A REMOTE COMMUNICATIONS ASSISTANCE CONCEPT

NAVY PERSONNEL RESEARCH
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EXAMINING THE FEASIBILITY OF A REMOTE COMMUNICATIONS ASSISTANCE CONCEPT

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Delays encountered when off-ship technical assistance is required to correct equipment casualties may be detrimental to overall operational readiness. Mission-essential equipment may be out of service for a long period of time before it can be repaired by a designated technical expert. One possible way to reduce the amount of time that a ship spends in a degraded state of equipment readiness at sea is to link expert repair technicians on shore to deployed units of the fleet using modern satellite communications technology. This report describes a controlled land-based test of the remote maintenance

assistance concept and identifies factors that may affect the efficiency of such a procedure when troubleshooting Navy equipment casualties.

FOREWORD

This research and development was conducted in support of independent exploratory development task ZF66.512.001.070 (Methods for Improving Maintenance Procedures), work unit 03.07 (Remote Expertise for Maintenance). The sponsor was the Chief of Naval Operations (OP-115). The project was initiated by the Navy Personnel Research and Development Center to examine the feasibility of employing remote communications between highly qualified shore-based technicians and at-sea maintenance personnel for use in the diagnosis and repair of equipment casualties.

Appreciation is expressed to the Commander, Fleet Anti-submarine Warfare Training Center, Pacific, San Diego, for providing sonar maintenance instructors who served as expert repair technicians for the demonstration study and to the Commanding Officers of USS MARVIN SHIELDS (FF 1066), USS DOWNES (FF 1070), and USS FIFE (DD 991) for providing the surface sonar technicians who served in the roles of at-sea maintenance personnel.

Special appreciation is expressed to members of the Weapon Control and Sonar Department, Code 62, Naval Ocean Systems Center (NAVOCEANSYSCEN) for providing access to equipment and facilities used during the demonstration study, particularly to Mr. Alvin Rhiner, NAVOCEANSYSCEN (Code 6222), who selected the troubleshooting problems and provided valuable assistance as a consultant.

JAMES F. KELLY, JR.	JAMES J. REGAN
Commanding Officer	Technical Director

SUMMARY

Problem

A ship generally requests shore-based technical assistance when its own personnel are unable to diagnose and repair an equipment casualty. Such casualties may constitute only a limited portion of the maintenance problems encountered in the fleet; however, they are especially detrimental to overall operational readiness because of the lengthy delays usually encountered before technical assistance is provided. One possible way to reduce the time that a ship spends in a degraded state of equipment readiness at sea is to link it to an expert technician on shore using modern satellite communication technology. The feasibility and practicality of this remote communications assistance concept need to be explored.

Objectives

The objectives of this effort were to (1) demonstrate the feasibility of troubleshooting at a distance and (2) identify factors that may affect the efficiency of this type of performance-aiding concept.

Approach

Troubleshooting problems representative of those requiring outside technical assistance were inserted in the AN/SQR-17 sonar detecting-ranging set in two demonstration sessions. For each session, an SQR-17 maintenance instructor from the Fleet Antisubmarine Warfare Training Center, Pacific (FLEASWTRACENPAC), San Diego served as the remote maintenance technician (or expert), while second and third class surface sonar technicians (STG2s and STG3s) from the fleet served as shipboard (or attendant) technicians. A two-way communication link between the expert and attendant technicians was established via an audio intercommunication system. For Session 1, a video link was also provided to allow the expert to view those portions of the equipment that would provide information of potential relevance to the troubleshooting situation. For Session 2, the expert was instructed to use the video link only in those cases where he could no longer proceed with troubleshooting on the basis of audio information alone.

Three troubleshooting problems were inserted in the SQR-17 for each session. The problems were identical in both cases, but their order of presentation varied between sessions. For each problem, conversations between the expert and attendant technicians were recorded and the total time spent in troubleshooting was noted.

Findings

The remote maintenance technicians were successful in solving five of the six troubleshooting problems inserted in the SQR-17 sonar. The sixth problem was terminated before being solved due to a time restriction imposed by the testing schedule. Actual conversation time between expert and attendant technicians accounted for an average of 17 percent of the total troubleshooting time across all problems. When visual information was provided, the expert technicians were only interested in viewing limited portions of the sonar set and supporting test equipment. For one problem in Session 2, the expert technician pursued a lengthy and ineffective troubleshooting strategy because of an imprecise description of casualty symptoms. When he requested video information to confirm the casualty symptoms, he was able to locate and solve the problem in less than 30 minutes.

Conclusions

1. To the extent that the current study was able to simulate the conditions under which remote communications assistance would be provided, the feasibility of this concept was demonstrated.

2. The large proportion of time spent in nonconversational activity for each troubleshooting problem suggests that the communications link need not be available on a continuous basis during the course of a remote communications assistance event.

3. Expert maintenance technicians must be provided with a precise verbal description of all relevant symptoms of an equipment casualty to facilitate timely and effective troubleshooting strategies when remote communications assistance is employed using an audio link exclusively.

Recommendations

1. The level of communications technology necessary to handle various classes of Navy equipment casualties (i.e., audio only vs. such extra-audio telecommunications capabilities as slow-scan television, electronic telewriter, facsimile processor) should be determined.

2. The feasibility and practicality of a time-sharing arrangement over the remote communications assistance network should be investigated. Such an arrangement could enable shore-based technicians to assist a number of deployed units over a single communications channel or, alternatively, to provide maintenance- or training-related services to the unit that requested shore-based assistance (e.g., transmission of new or updated technical documentation, equipment drawings, and diagrams via facsimile equipment, or the delivery of incidental on-the-job maintenance training).

3. A standard procedure for requesting and/or delivering remote communications assistance should be developed. This procedure should be designed to increase the precision with which attendant and expert technicians discuss equipment symptoms or appropriate troubleshooting and repair strategies and could reduce the amount of time spent in two-way interaction over the communications network.

CONTENTS

INTRODUCTION

Problem

A ship usually requests shore-based technical assistance when its own personnel are unable to diagnose and repair an equipment casualty. Such casualties may constitute only a limited portion of the maintenance problems encountered in the fleet; however, they are especially detrimental to overall operational readiness because of the lengthy delays usually encountered before technical assistance is provided. One possible way to reduce the time that a ship spends in a degraded state of equipment readiness at sea is to link it to an expert technician on shore using modern communications satellite technology. The feasibility and practicality of this remote assistance concept as an alternative to current methods for obtaining off-ship technical assistance need to be explored.

Objectives

The objectives of this effort were to (1) demonstrate the feasibility of troubleshooting at a distance and (2) identify factors that may affect the efficiency of this type of performance-aiding concept.

Background

The concept of remote communications assistance is not particularly new, nor is it restricted to equipment troubleshooting and repair. The use of interactive television to facilitate the delivery of medical care, telemedicine, was first introduced in the United States in 1964. A closed-circuit television link was installed between the Nebraska Psychiatric Hospital in Omaha, Nebraska and the Norfolk State Hospital, 112 miles away. Although the Nebraska telemedicine project was used primarily for psychiatric consultation and administrative purposes, the transmission of reasonably detailed physical diagnosis information was successfully demonstrated.

Since 1964, some two dozen telemedicine programs, both civilian and military, have been conducted in the United States. (See Harrison,[1] for a complete bibliography of telemedicine programs and research applications.) In addition to the use of interactive television links to substitute for in-person contact between patients and physicians, current telecommunications technology enables a wide range of medical diagnostic information (e.g., electrocardiograms (EKGs), electroencephalograms (EEGs), and views of bacteria, tissue, and blood samples under a microscope) to be transmitted over large distances.

The use of remote communications assistance in rectifying serious at-sea equipment problems involving commercial ships was recently described in a report[2] prepared for the Naval Sea Systems Command (NAVSEASYSCOM). In 1977, for example, a commercial ship sustained an engineering casualty that led to a complete failure of its propulsion

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[1]Harrison, E. A. Telecommunications in Medicine, 1964-June 1980 (Citations from the NTIS Data Base) (NTIS No. PB80-812720). Springfield, VA: National Technical Information Service, July 1980.

[2]American Management Systems, Inc. SEASTARS, Technological Feasibility Study and Preliminary Rest Report (Contract N00024-79-C-5683). Arlington, VA: Author, December 1980, pp. 37-38.

system. The ship's engineers were unable to correct the problem and the nearest towing vessel was several thousand miles away. Design and building engineers spent 12 hours on a commercial marine satellite (MARISAT) voice circuit with engineers aboard the stricken ship, and the casualty was repaired to the extent that the ship made port without assistance. Another more dramatic at-sea incident occurred in mid-1979. A large liquified natural gas carrier ran aground near the Strait of Gibraltar and suffered extensive hull and machinery damage. Through the use of MARISAT, ship's personnel were able to obtain repair guidance and arrange for the immediate transfer of the ship's cargo.

The technological feasibility of establishing a ship-to-shore communications link between at-sea maintenance personnel and expert technicians ashore for assistance in troubleshooting and repairing Navy equipment casualties was demonstrated in a project entitled Shipboard Engineering Assistance for System Test and Repair via Satellite (SEASTARS).[3] A SEASTARS project team, under the direction of NAVSEA 62C, addressed several equipment-related issues in evaluating the technological feasibility of the remote communications assistance concept:

1. Determining the most suitable communications system delivery vehicle with which to conduct an operational test of the SEASTARS concept.

2. Identifying various extra-audio telecommunication equipment (e.g. slow-scan television, electronic telewriter, facsimile processor) that would provide a full range of interactive services to facilitate the delivery of technical assistance.

3. Examining the feasibility of encoding voice and other communications accessory equipment transmissions using a standard Navy encryption device, as well as examining the inter- and intrasystem compatibility.

Although the SEASTARS project team demonstrated the feasibility and technological compatibility of various equipments that would support a remote communications assistance network, *it did not* provide a feasibility demonstration (either directly or through simulation) of this maintenance concept. Therefore, this study was undertaken to provide such a demonstration and to identify factors that might affect the use of such a procedure when troubleshooting Navy equipment casualties.

APPROACH

Troubleshooting Problems

The equipment involved in the demonstration study was the AN/SQR-17 sonar detecting-ranging set. Prefaulted circuit cards were inserted in the system to provide realistic equipment casualties. The faults had previously been developed for another SQR-17 maintenance demonstration project conducted at the Naval Ocean Systems Center (NAVOCEANSYSCEN), San Diego from February to April 1981. The troubleshooting problems included in the NAVOCEANSYSCEN project that proved to be too difficult for fleet second and third class surface sonar technicians (STG2s and STG3s) to diagnose and repair were selected for use in this study. It was felt that these problems were representative of those for which STG2s and STG3s would request some form of technical assistance.

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[3]Ibid.

Subjects

Two AN/SQR-17 sonar maintenance instructors from the Fleet Anti-submarine Warfare Training Center, Pacific (FLEASWTRACENPAC), San Diego served as the remote maintenance technicians (or experts). The instructors, an STGC and an STG1, had extensive training and fleet experience in maintenance of the SQR-17. Three STG job incumbents from the fleet (i.e., two STG2s and one STG3) served in the roles of at-sea maintenance personnel, termed attendant technicians. They had entry-level training and experience in SQR-17 sonar maintenance.

Procedures

Two sessions were conducted in an experimental laboratory at NAVOCEANSYSCEN to examine the feasibility of the remote communications assistance concept. In both sessions, a two-way voice communication link between the expert and attendant technicians was established via an audio intercommunication system.

For Session 1, the troubleshooting team consisted of an STGC maintenance instructor and one STG2. A video link was provided for each troubleshooting problem so that the expert could view those portions of the equipment that would provide information relevant to the troubleshooting situation. For Session 2, the troubleshooting team consisted of an STG1 maintenance instructor, an STG2, and an STG3. During this session, the expert was instructed to use the video link only in those cases where he could no longer proceed with troubleshooting on the basis of audio information alone.

The attendant technicians were stationed at the equipment site and were responsible for reporting the symptoms associated with each casualty to the expert technician. Due to time limitations imposed by the testing schedule, the attendants were instructed not to perform any system troubleshooting on their own prior to establishing the communication link with the expert. Instead, a detailed explanation of all relevant symptoms for each equipment casualty was provided to the attendants before each troubleshooting problem started. Attendant technicians were also responsible for performing various fault isolation tests using standard Navy test equipment and for removing and replacing printed circuit cards as directed by the expert.

The expert technician was stationed in an adjacent room. He was instructed to direct the attendant(s) verbally in troubleshooting and repairing the equipment casualties and, as applicable, to direct the television camera to various portions of the sonar system or supporting test equipment. For both sessions, separate sets of AN/SQR-17 maintenance manuals and schematic diagrams were provided to the expert and attendant technicians.

Three faults were inserted in the SQR-17 sonar for each session. The faults were identical in both cases, but their order of presentation varied between sessions. For each troubleshooting problem, conversations between the expert and attendant technicians were recorded and the total time spent in troubleshooting noted. Although no formal time limits were established for completing each troubleshooting problem, FLEASWTRACENPAC instructors were only available for a limited time period (i.e., 4 hours) for each demonstration session. As a result, troubleshooting was terminated when the total time allocated for each session had been exceeded. This occurred once during the two sessions.

It should be noted that demonstrating the feasibility of troubleshooting Navy equipment casualties at a distance addresses only a part of the larger question concerning the overall operational feasibility of a remote communications assistance concept. By its

very nature, use of this technique depends greatly upon the availability of dedicated Navy (or other commercially-available) satellite communication channels. Because these channels are used extensively at the present time, it was important to determine the extent to which the communication link was actually used for conversation related to troubleshooting. Therefore, a second aspect of the current study concerned the amount of time that the communication link was actually being used in relation to the total time spent in troubleshooting each problem. Audio recordings for each troubleshooting problem were analyzed to determine: (1) the amount of time spent in active conversation between the expert and attendant technicians, defined as essentially uninterrupted dialogue with pauses or other hesitations not exceeding 15 seconds, and (2) time periods characterized by delays that were clearly of a nonconversational nature (i.e., those in excess of 15 seconds during which equipment symptoms were written down, various troubleshooting tests were performed, technical manuals were consulted, and so on).

RESULTS

A primary concern in the examination of the remote communications assistance concept was the success or failure of the expert technician in diagnosing and repairing the equipment casualties from a remote location. Of the six casualties inserted in the SQR-17, five were successfully diagnosed and repaired by the remote expert maintenance technicians. The sixth problem was terminated before being solved due to a time restriction imposed by the testing schedule.

As shown in Table 1, actual conversation time accounted for a limited proportion of the total time spent in troubleshooting each problem (i.e., an average of 17% of the total troubleshooting time across all problems). The remaining time was spent in nonconversational activities (described above).

Table 1

Comparison of Total Troubleshooting Time to Conversation Time

	Session 1 Troubleshooting Time (Audio and Video)			Session 2 Troubleshooting Time (Audio-Video as needed)		
Fault Card Number	Total Time (Min)	Conversation Time (Min)	Percent Conversation Time	Total Time (Min)	Conversation Time (Min)	Percent Conversation Time
4118	55	9.3	17	15	3.4	23
4114	75	14.0	19	125	20.3	16
6134[a]	80	12.3	16	35	4.6	13

[a]Problem not solved during Session 1.

Table 2 shows how the actual conversation time for each troubleshooting problem was divided between the expert and attendant technicians. On the average, it was found that the expert technicians spent twice as much time in communicating as did the attendant technicians (i.e., 66 vs. 33% respectively).

Table 2

Comparison of Expert vs. Attendant Technician Conversation Time

Fault Card Number	Session 1 Conversation Time				Session 2 Conversation Time			
	Expert Technician		Attendant Technician		Expert Technician		Attendant Technician	
	Time (Mins)	Percent	Time (Mins)	Percent	Time (Mins)	Percent	Time (Mins)	Percent
4118	5.1	55	4.2	45	2.6	76	0.80	24
4114	9.4	67	4.6	33	13.4	66	6.9	34
6134[a]	6.9	56	5.4	44	3.4	73	1.2	27

[a]Problem not solved during Session 1.

With respect to qualitative findings, a general pattern was established in the types of interactions that occurred between the expert and attendant technicians for each troubleshooting problem. First, the attendant provided a verbal description of the symptoms associated with each problem in various operational modes. When the expert had confirmed these symptoms (either verbally or visually), the interaction changed. The expert began directing the attendant's behavior by either asking him specific questions or giving him explicit instructions concerning the troubleshooting procedure to be performed.

With respect to utilization of the video information, the expert technicians were only interested in viewing the CRT display on the SQR-17 or the oscilloscope. The visual information was used by the experts for comparison with illustrations from maintenance manuals or for confirmation of the casualty symptoms. Video information was not requested by the expert technicians for other aspects of troubleshooting (e.g., removing and replacing printed circuit cards, checking test points) that were performed by the attendant technicians at the equipment site.

Finally, in regard to the second demonstration session, the expert technician only requested video information for a single troubleshooting problem (involving fault card 4114). Referring back to Table 1, it can be seen that the total time required for solution of this problem (in Session 2) was much longer than that required for the other troubleshooting problems (i.e., 125 minutes). This discrepancy probably arose from the attendant's imprecise verbal description of the equipment casualty symptoms; a situation that resulted in the expert pursuing an inappropriate troubleshooting strategy. After more than 90 minutes of troubleshooting on this problem, the expert and attendant

technicians were not much further ahead than when they started. At this point, the expert requested a video transmission of the CRT display on the SQR-17. When this was provided, the expert was able to locate and solve the problem in less than 30 minutes.

DISCUSSION

Although the current effort was limited to a very small sample of maintenance technicians and troubleshooting tasks, this study demonstrated the feasibility of the remote communications assistance concept. Moreover, the results have implications for follow-on Navy research and development efforts to improve the efficiency and effectiveness of the concept.

The number of troubleshooting problem solutions obtained in both sessions (i.e., five or six problems were solved) was considered to be of practical significance in demonstrating the feasibility of the remote assistance concept, given that the problems had been documented by NAVOCEANSYSCEN engineers as too difficult for the attendant technicians to solve on their own. It is interesting to note that using alternative communication modes produced similar results in terms of troubleshooting solutions. However, the current effort focused on only one type of troubleshooting activity (i.e., isolating faulty printed circuit cards) and tested the feasibility of the concept using a single expert technician for each type of communication linkage (i.e., the audio plus video condition vs. the audio-video as needed condition). A larger-scale experiment involving a broader range of troubleshooting tasks and telecommunication linkages (e.g., facsimile transmissions, electronic telewriters) might identify equipment casualty classes that are more readily detected and solved by using one type of communication linkage over another. The question arises, therefore, as to the level of communication technology necessary to handle various classes of equipment casualties.

A long-term research and development goal might be a mapping of alternative telecommunication linkages onto classes of troubleshooting problems, indicating the relative effectiveness of each in detecting various equipment problems. Given this information, expert maintenance technicians would be in a far better position to select the most appropriate telecommunications linkage to provide remote communications assistance to deployed units of the fleet. Data from the current Navy Consolidated Casualty Reporting (CASREP) System[4] or other management, engineering, and analyst reports for selected Navy equipments,[5] may provide some of the information needed to initiate this research.

The large proportion of time spent in noncommunication activities for each troubleshooting problem suggests that some sort of time-sharing arrangement should be considered in further exploration of the remote communications assistance concept. Such an arrangement could, for example, enable shore-based technicians to provide simultaneous services to a number of deployed units using a single communications channel. Should such a time-sharing arrangement prove feasible, further research is needed to determine the information load that an expert maintenance technician can tolerate (i.e., the number of equipment casualties that an expert could handle

[4]Navy Ships Parts Control Center. Consolidated Casualty Reporting System CASREP) Reports Catalog (7th ed.). Mechanicsburg, PA: Author, October 1978.

[5]Naval Sea Systems Command Detachment. Fleet-MDS-CASREP Maintenance and Engineering Analysis (NAVSEA 0967-535-7010). Norfolk, VA: Author, June 1977.

simultaneously). Alternatively, significant portions of nonconversation time over the communications link could be used to provide maintenance- or training-related services to the platform that requested shore-based technical assistance. Examples include the transmission of new or updated technical publications, equipment drawings or diagrams via facsimile equipment, or delivery of incidental on-the-job training to shipboard technicians during a remote technical assistance event.

It was found that an imprecise verbal description of the equipment casualty symptoms provided by an attendant technician during the second demonstration session hampered both the troubleshooting effectiveness and efficiency of the expert technician. This finding suggests that, if remote communications assistance uses an audio link exclusively, the expert must be provided with a precise description of all relevant symptoms of an equipment casualty to facilitate the use of timely and appropriate troubleshooting strategies. The development of a standard procedure for requesting and/or delivering remote communications assistance may provide a method for increasing the precision with which expert and attendant technicans communicate. The feasibility and practicality of such communication procedures requires further exploration.

CONCLUSIONS

1. To the extent that the current study was able to simulate the conditions under which remote communcations assistance would be provided, the feasibility of the remote communcations assistance concept was demonstrated.

2. The large proportion of time spent in nonconversation activity for each troubleshooting problem suggests that the communication link need not be available on a continuous basis during the course of a remote communication assistance event.

3. Expert maintenance technicians must be provided with a precise verbal description of all relevant symptoms of an equipment casualty to facilitate timely and effective troubleshooting strategies when remote communications assistance is employed using an audio link exclusively.

RECOMMENDATIONS

1. The level of communications technology necessary to handle various classes of Navy equipment casualties (i.e., audio only vs. such extra-audio telecommunications capabilities as slow-scan television, electronic telewriter, facsimile processor) should be determined.

2. The feasibility and practicality of a time-sharing arrangement over the remote communications assistance network should be investigated. Such an arrangement could enable shore-based technicians to provide assistance to a number of deployed units over a single communications channel or, alternatively, to provide maintenance- or training-related services (e.g., transmission of new or updated technical documentation, equipment drawings, and diagrams via facsimile equipment or delivery of incidental on-the-job maintenance training) to the unit that requested shore-based assistance.

3. A standard procedure for requesting and/or delivering remote communications assistance should be developed. This procedure should be designed to increase the precision with which attendant and expert technicians discuss equipment symptoms or appropriate troubleshooting and repair strategies and could reduce the amount of time spent in two-way interaction over the communications network.

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